[SHORT RESEARCH REPORT]

# Enhancing seedling survival on former floodplain grazing land in the Capertee Valley, Australia

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## Summary

Active revegetation is an essential component of biodiversity conservation for fragmented ecosystems and the species that depend on them. However, key knowledge gaps exist around the most cost-effective revegetation strategies to employ in different contexts. This article reports on a revegetation trial undertaken in the Capertee Valley of New South Wales, Australia, to assist the conservation of the critically endangered bird, the Regent Honeyeater (*Anthochaera phrygia*). Seven treatments were compared to assess their cost-effectiveness for enhancing plant survival at a floodplain site with a history of grazing on introduced pastures. While overall survival rates were low, treatments involving tree guards had higher survival rates and were more cost-effective than treatments without guards. Weed growth, animal activity and water stress all appeared to play a role in the low survival rates at this site, with enhanced weed control emerging as a priority for future trials at similar sites.

**Key words**

Revegetation, tree guards, macropods, Regent Honeyeater, weeds and weed control, riparian

**Introduction**

Habitat loss and fragmentation are major threats to biodiversity worldwide, with bird habitat in agricultural landscapes being a key focus area for revegetation efforts (Vesk and Mac Nally 2006). This article reports on a trial undertaken between July 2014 and June 2016 to compare methods for the establishment of local native trees on floodplain sites in Capertee National Park, NSW, Australia.

The Capertee Valley is a key breeding habitat for the critically endangered Regent Honeyeater (*Anthochaera phrygia*), with the National Recovery Plan for the species emphasising the importance of habitat restoration. BirdLife Australia's Capertee Valley Regent Honeyeater Recovery Group has been undertaking revegetation activities since the mid-1990s. However, reluctance amongst private landholders to set aside productive floodplain areas has meant that most revegetation in the valley has been undertaken on slopes and ridges. As such, there is a knowledge gap around the most cost-effective ways to restore floodplain areas, which represent important feeding and nesting sites for the Regent Honeyeater.

The gazettal of Capertee National Park in 2011 presented a unique opportunity to undertake a formal revegetation trial on prime floodplain grazing land. While a range of practices have been shown to enhance seedling survival and growth rates in different contexts, including weed treatment, tree guards, animal repellents and watering, a review of revegetation techniques by Graham et al. (2009) emphasises that the effectiveness of many of these practices is dependent on local conditions. As such, this trial was aimed at comparing the cost-effectiveness of common revegetation techniques used in the Capertee Valley and some alternative approaches that have been successful in other locations.

**Methods**

*The site*

Capertee National Park was used for cattle and sheep grazing from the 1850s, with approximately 100 ha of floodplain sown with introduced pasture. A 10 ha site on the Capertee River was selected for the trial, located on a near-level floodplain dominated by pasture grasses, including *Phalaris* spp., *Paspalum* spp. and Kikuyu Grass (*Pennisetum clandestinum).*

Initial consultations with the National Parks and Wildlife Service (NPWS), BirdLife Australia and other key stakeholders identified high weed growth and macropod browsing by the Eastern Grey Kangaroo (*Macropus giganteus)* and Common Wallaroo (*Macropus robustus)* as key factors that could affect plant survival.

The site was initially laid out with 74 planting lines, five metres apart. However, only half of these lines were ultimately planted with seedlings (i.e. 37 lines, 10 m apart). An attempt at direct seeding on the other lines was abandoned due to high levels of weed growth. Lines were oriented north-south to ensure that each line had one end adjacent to the riverbank and one end away from it, as animal activity had been observed to be higher nearer the river. Lines varied from 82 m to 300 m in length.

*Preparation*

The site was sprayed with glyphosate 580 and slashed in October 2013. In March 2014 a repeat slashing and spraying was undertaken before each line was ripped to an average depth of 500 mm on 15 May 2014 (11 weeks prior to planting). Planting was carried out in July 2014 (winter). Seedlings were watered at the time of planting and again in November 2014 (summer), as rainfall was below average leading into the summer of 2014/15. Herbicide spraying took place in May 2015 (autumn) and slashing was undertaken adjacent to each line in March 2015, October 2015 and June 2016.

Seven plant species were selected based on what was believed to have been present prior to clearing. These were Blakely's Red Gum (*Eucalyptus blakelyi)*, Yellow Box (*Eucalyptus* *melliodora)*, Ribbon Gum (*Eucalyptus viminalis)*, Rough-barked Apple (*Angophora floribunda*), River Sheoak (*Casuarina cunninghamiana*), Fern-leaved Wattle (*Acacia filicifolia*) and Hickory Wattle (*Acacia implexa).* Seedlings were raised off-site, with most seeds collected from the national park (Fern-leaved Wattle and Hickory Wattle seeds collected off-site within 50km).

*Treatments*

In total, 1889 seedlings were planted 5 metres apart in 150 mL forestry tubes. Species were distributed randomly along each line. The number of seedlings per line varied between 15 and 71, depending on the length of the line. Each planting line was randomly assigned one of seven different treatments, resulting in 5 or 6 replicates of each treatment. Each line was treated as a single replicate regardless of length. The treatments were:

1. Plant only
2. Basic guards – white waxed fibreboard, 300 mm high, 2 litre volume, supported by two bamboo stakes
3. Medium guards – green corflute, 3-sided, 450 mm high, supported by one wooden stake
4. High guards – black plastic mesh with 20 mm x 20 mm grid, 900 mm high, supported by two bamboo stakes
5. Sen-Tree™ – applied to the leaves of each plant at time of planting
6. Blood and bone – 200 g applied to the soil surrounding each plant at time of planting
7. Basic guards combined with blood and bone

Guards were used in four of the seven treatments, as they are commonly used in the Capertee Valley and previous studies have shown that they may protect seedlings against a diverse range of threats including herbivory, weeds and high temperatures (Allcock and Hik 2004; Graham et al. 2009; Ladd et al. 2010).

Treatment 2 (basic guards) was designed to simulate the most common planting approach employed by BirdLife Australia's Regent Honeyeater Recovery Group. Treatment 3 (medium guards) employed corflute guards that had been reported as achieving high survival rates in some local plantings (unpublished). Treatment 4 (high guards) used 900 mm high plastic mesh to prevent browsing by macropods and simulate the effect of exclusion fencing, which was shown by Allcock and Hik (2004) to enhance seedling survival at nearby Burrendong Dam.

Treatments 5, 6 and 7 all involved repellents to deter browsing, with Sen-Tree™ and blood-and-bone selected based on the results of Forestry Tasmania studies aimed at addressing possum and macropod damage (Miller et al. 2008). Sen-Tree™ is a commercial product that employs a combination of egg solids (odour repellent), PVA (bonding agent) and carborundum (silicon carbide grit that acts as a physical deterrent to browsing).

*Data collection and analysis*

Monitoring was undertaken at the following intervals after planting: 1 month, 3 months, 6 months, 1 year, 1.5 years and 2 years. Plants with uncertain survival status (e.g. desiccated leaves and stems) were recorded as surviving at the 1-month and 3-month monitoring events, but not from the 6-month event onwards.

The key measure used to compare treatments was survival rate per line (%) after two years. Raw survival rates were also adjusted to produce a cost-effectiveness score for each treatment (number of plants surviving after two years per $1000 spent). This included direct costs such as seed collection, nursery costs, planting costs and other preparation and maintenance activities performed by contractors, as well as indirect costs related to site preparation and maintenance activities performed by park managers.

Statistical analysis was undertaken on the survival rates and cost-effectiveness scores for each treatment. One-way analysis of variance (ANOVA) tables were generated to test for differences across all seven treatments, with Tukey's significant difference test then used to compare individual treatments to one another. One-tailed t-tests were also used to compare all lines with some form of guard (i.e. treatments 2, 3, 4 and 7 combined) to those with no guards (treatments 1, 5 and 6) for both survival rate and cost-effectiveness.

Statistical methods followed Mason et al. (2003 p. 194-213), with an α value of 0.05 used for all tests.

## Results

*Observations*

The overall survival rate was low (10% after two years). General observations included signs of desiccation (especially during the first 3 months), evidence of animal movement (disturbed guards, scats and paths) and high levels of weed growth. Animal activity appeared to be higher near the river and some plants were damaged in ways consistent with animal encounters. Weed presence was low at the time of planting (winter 2014), but increased soon after and the whole site was covered in pasture grasses up to 1 m high each summer. The eucalypt species tended to survive best, especially Blakely's Red Gum, but the study design did not allow for this to be tested statistically.

The three treatments without guards suffered high early mortality, with survival rates for each falling below 10% by the 6-month mark. In contrast, the four treatments with guards took longer to decline and remained above 10% survival after 2 years (Figure 1). Overall, the lines treated with medium guards (Treatment 3) showed the highest mean survival rate. The high guards were observed to be the most robust (i.e. remained standing longest), followed by the medium guards, then basic guards. However, the open plastic mesh of the high guards did not appear to provide as effective a barrier to weeds as the medium guards.

[Figure 1 here]

*Statistical analysis*

The ANOVA comparing the mean survival rate per line after two years across the seven treatments showed a significant result at $\alpha = 0.05$ (p-value = 0.030). However, when Tukey's significant difference test was used to compare treatments pairwise, the only pair of treatments that showed a significant difference in survival rate was Treatment 3 (medium guards) and Treatment 6 (blood and bone), which had the highest and lowest mean survival rates respectively (q-value of 4.65, exceeding q-critical of 4.60).

The cost-effectiveness score was based on the number of plants surviving in each line after two years per $1000, taking account of the costs of each treatment, which were highest for the high guards and lowest for plant only. The ranking of treatments for mean cost-effectiveness was the same as for mean survival rate (i.e. medium guards highest, blood and bone lowest). However, the ANOVA test comparing the cost-effectiveness of each treatment did not show a significant difference (p-value = 0.073). Due to the lack of a significant difference, no comparisons between pairs of treatments were made.

The final statistical tests involved all 21 lines treated with some form of guard (i.e. Treatments 2, 3, 4 and 7 combined) being compared to the 16 lines without any guard (Treatments 1, 5 and 6 combined) using one-tailed t-tests. These tests showed a significant difference for both survival rate and cost-effectiveness (plants surviving per $1000 spent). The P-value was 0.000035 for survival rate and 0.0036 for cost-effectiveness, both well below the selected $\alpha$ value of 0.05.

## Discussion

The low survival rates across all treatments highlight the challenges of revegetating floodplain sites that have been subject to grazing on introduced pastures using typical revegetation strategies practiced in the Capertee Valley. Despite the low survival rates, the trial provided evidence that some form of guard is likely to be more effective than no guard at a site such as this, in terms of both survival rate and cost-effectiveness. The trial was less conclusive in differentiating between different types of guard. The medium guards (corflute, 450 mm high) had the highest mean survival rate and mean cost-effectiveness score, but the differences between these guards and the other guards were not statistically significant.

Observations made during the trial indicate that animal browsing, weed growth and dry conditions may have impacted on seedling establishment at this site. However, the trial did not gather strong evidence on the relative importance of these factors. While the treatments were primarily selected based on their potential to reduce animal impacts, weed growth and desiccation was greater than expected. These factors could be explored further in future trials at similar sites.

Water stress (and possibly frost) appeared to impact on early survival rates, particularly for plants without guards. Alternative methods may be able to reduce this, such as additional watering, which Ruthrof et al. (2013) found to increase growth and survival in a Western Australian trial. However in this trial it is unlikely that water stress was the dominant factor affecting survival, as different treatments suffered major mortality episodes at different points over the 2 years of the trial. Furthermore, a nearby BirdLife Australia planting established at a similar time with similar species, guards and preparation reported a much higher survival rate of 84% after one year (*Richard Turner, Birdlife Australia, August 2015,* unpublished data). One key difference is that, unlike the trial site, the Birdlife Australia site was situated on a ridgeline with rocky soils and a much lower weed presence.

Previous studies highlight a number of techniques that could be employed in future trials to control weed growth. Ladd et al. (2010) found that tree growth in a South Australian trial was significantly higher where guards were combined with herbicide application and the use of black polypropylene weed mat. Jute matting or mulch may be alternative options.

Scalping could be employed to reduce weed impacts, with Gibson-Roy et al. (2010) finding it to be more effective at preventing regrowth than the use of herbicides in a trial in Victoria. However, scalping can be more expensive than other weed control options and can pose risks such as exposing poorly structured subsoils and loss of moisture and nutrient holding capacity (Close and Davidson 2003). It may be possible to minimise negative impacts by only scalping a small area around each seedling.

All three types of guards used in this trial warrant further investigation in conjunction with weed matting, scalping and/or increased herbicide application. A scalping approach could also allow the cost-effectiveness of tubestock planting to be compared with that of direct seeding, which was not possible in this trial due to the high levels of weed growth. Other factors that could be analysed in future studies include the potential impact on cost-effectiveness of reusing guards (which appears to be greater for corflute guards than for fibreboard guards) and the comparative costs of planting by volunteers versus commercial contractors. Alternative animal control measures could also be tested, such as dingo urine (Parsons and Blumstein 2010).

In conclusion, the trial produced very low survival rates and indicated that typical approaches to revegetation that have been successful on less fertile and hillier areas of the Capertee Valley may not be effective for floodplain sites with a history of grazing on introduced pastures. The trial showed that some type of guard is better than none in terms of cost-effectively enhancing seedling survival at such sites, but further trials are required that focus on the use of guards in combination with measures such as weed mats, scalping, increased use of herbicides, greater ripping depths and/or supplementary watering.

**Abbreviated acknowledgements**

This project was funded through a grant from the NSW Environmental Trust.

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**Figures**

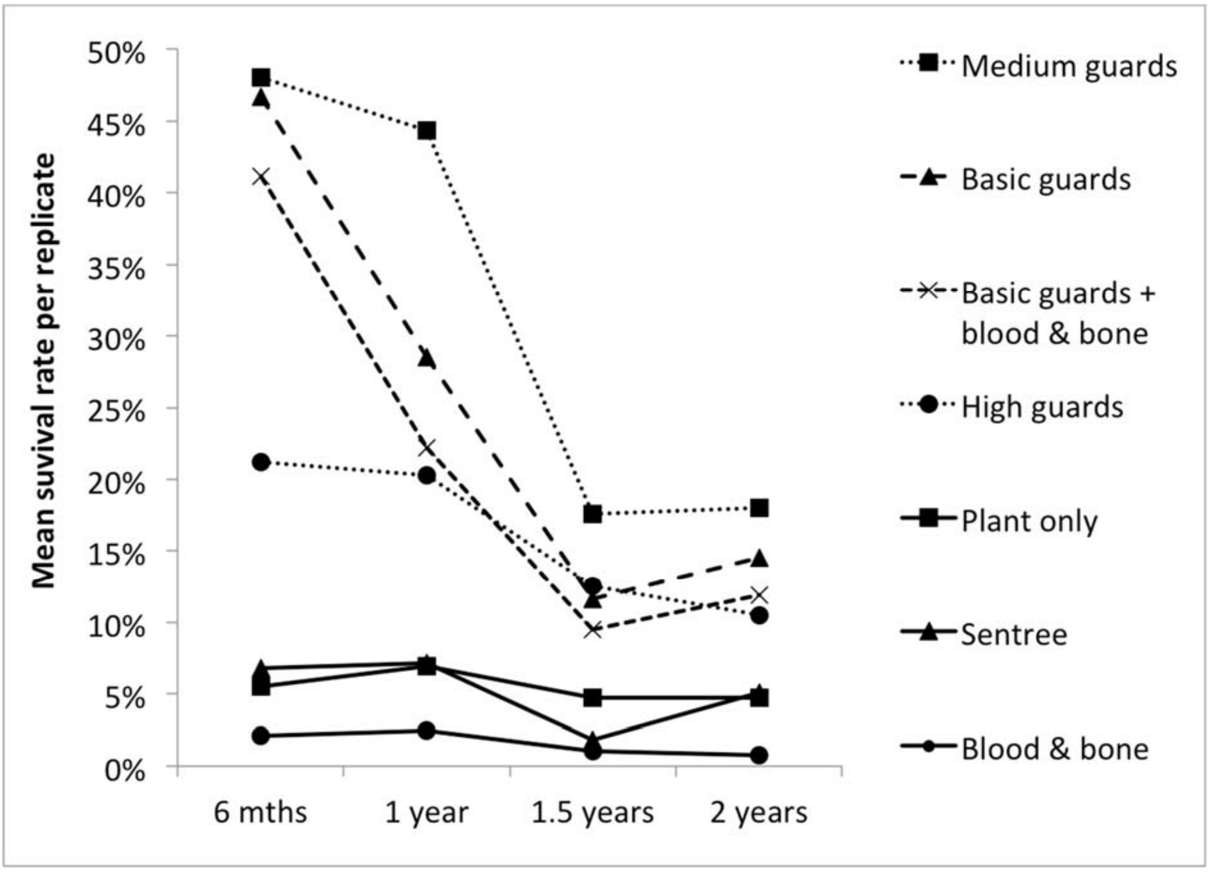


**Figure 1: Mean survival rate over 2 years amongst replicates of each treatment**. The pattern of higher survival in winter (i.e. at 1-year and 2-years) relative to summer (i.e. 6-month and 1.5 years) for some treatments is likely to be erroneous due to plants being more difficult to locate amongst high grass growth in summer.